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February 18, 1997

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street
Washington, D.C. 20554

Re: Restrictions on Over-the-Air Reception Devices: Television Broadcast and Multichannel Multipoint Distribution Service
IB Docket No. 95-59; CS Docket No. 96-83
WRITTEN EX PARTE COMMUNICATION

Dear Mr. Caton:

On behalf of the NBC Television Network Affiliates Association, the ABC Television Network Affiliates Association and the CBS Television Network Affiliates Association (collectively, the "Network Affiliated Stations Alliance" or "NASA"), I am submitting the enclosed comments, which are being filed on this date in the Commission's proceeding concerning the request of Jay Lubliner and Deborah Galvin for a declaratory ruling regarding the Potomac Ridge Homeowners Association's prohibition on outdoor antenna installations.[1/] Because the issues described in the comments are closely related to issues raised in NASA's petition for reconsideration in this proceeding, NASA requests that the comments be included in the record of this proceeding.

In accordance with the requirements Section 1.1206(a) of the Commission's Rules, an original and one copy of this letter are being submitted to the Secretary's office.

Respectfully submitted,

J.G. Harrington

JGH/taf
Enclosure

No. of Copies rec'd 0+1
List ABCDE

1/ *See* "Petition Filed Seeking Declaratory Ruling that Certain Provisions of a Homeowners Association Covenant Are Preempted by the Commission's Over-the-Air Reception Devices Rule," Public Notice, DA 97-118 (rel. Jan. 16, 1997).

RECEIVED
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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the matter of	)	
	)	
Petition of Jay Lubliner and Deborah Galvin for Declaratory Ruling Regarding Restrictions on Outdoor Antenna Installations by Potomac Ridge Homeowners Association	)))))	Case ID CSR-4915-O

COMMENTS OF THE NETWORK AFFILIATED STATIONS ALLIANCE

The NBC Television Network Affiliates Association, the CBS Television Network Affiliates Association and the ABC Television Network Affiliates Association (together, the "Network Affiliated Stations Alliance" or "NASA") hereby submit their comments in response to the Commission's Public Notice in the above-referenced proceeding.[1] As shown below, the petition for declaratory ruling in this proceeding should be granted. The covenants at issue are directly contrary to the requirements of Section 207 of the 1996 Act, and the homeowners association's interpretation of Section 207 is untenable.[2] Indeed, this proceeding illustrates the importance of specific Commission guidance regarding impermissible restrictions on the placement of television antennas.

1/ "Petition Filed Seeking Declaratory Ruling that Certain Provisions of a Homeowners Association Covenant Are Preempted by the Commission's Over-the-Air Reception Devices Rule," DA 97-118 (rel. Jan. 16, 1997). These comments also are being submitted as a written ex parte communication in the Commission's over-the-air reception devices proceeding. *Preemption of Local Zoning Regulation of Satellite Earth Stations, Implementation of Section 207 of the Telecommunications Act of 1996, Restrictions on Over-the-Air Reception Devices: Television Broadcast Services and Multichannel Multipoint Distribution Service,* Report and Order, Memorandum Opinion and Order, and Further Notice of Proposed Rulemaking, IB Docket No. 95-59, CS Docket No. 96-83, rel. Aug. 6, 1996 (the *"Reception Devices Order"*).

2/ Telecommunications Act of 1996, Pub. L. 104-104, 110 Stats. 56 (1996) (the "1996 Act"), § 207.

The issue in this proceeding is whether or not a homeowner can use a rooftop antenna rather than being forced to use an indoor antenna. The homeowners association claims it can prohibit the use of rooftop antennas, just as it could before the 1996 Act. To make that claim, the association stretches Section 207 beyond its plain statutory language and rejects the Commission's expert determination of the meaning of the statute. The association's view should be rejected for three reasons.

First, as the Commission already has determined, under Section 207 an impairment occurs if the quality of an over-the-air signal is adversely affected.[3/] This is the plain meaning of "impair."[4/] The association's interpretation, which would require a signal to be "unacceptable" (by standards it does not disclose) contradicts both the Commission's determination of the meaning of the statute and common sense. If Congress had meant to preclude only regulations that prevent the viewing of "acceptable" over-the-air broadcasts, "unacceptable" is the word it would have used in the statute.

Second, the association proposes that Section 207 should apply only when a homeowner is incapable of receiving *any* "acceptable" broadcast signal, rather than when the homeowner's ability to receive one or more signals is impaired.[5/] Again, this interpretation of the statute is contrary to a plain reading of the statute. If it were permitted to stand, Section 207 would be almost completely ineffective. Equally important, the association's

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3/ *Reception Devices Order,* ¶¶ 13, 20 (invalidating requirements that require antenna placement that "substantially degrade[s]" reception).

4/ *Id.*

5/ *See* Letter of Lenard Goldbaum to Jay and Deborah Lubliner, Sep. 30, 1996 at 1 ("the law very specifically protects only the ability to receive *a signal of acceptable quality*" not "the ability to receive all desired signals with high-quality viewing") (emphasis in original).

interpretation is violative of basic Commission policies dating back to the beginning of the television service that favor maximum service to all consumers. For instance, maximum service is a key element in the new table of allotments the Commission is considering in its Advanced Television proceeding.

Third, the association erred as a matter of fact when it claimed that requiring antennas to be inside a house would not impair reception. Elementary physics demonstrates that reception is necessarily worse inside a house (even from an attic) than from outside: Not only will the antenna be at a lower elevation, but there will be obstructions, such as the roof of the house, that would not affect an outdoor antenna. This theoretical effect has been confirmed repeatedly in practice. For instance, the Commission found in 1980 that indoor antennas produced a signal that was between 12 and 30 dB lower than outdoor antennas in typical installations.[6/] Thus, there can be no question that the covenant at issue here is an impairment in violation of Section 207 and that the Commission should declare it to be void.

The Commission also should take this opportunity to issue specific guidance regarding impermissible restrictions. It is apparent, despite the Commission's hopes when it issued the *Reception Devices Order,* that homeowners associations continue to seek loopholes that evade the intent of both Congress and the Commission. General guidance will not prevent continued efforts to unlawfully restrict over-the-air reception devices. Only specific, detailed requirements will suffice. Moreover, it is likely that general guidance will lead to increased litigation as homeowners associations attempt to exploit perceived ambiguities in the general policy. There is no benefit to any party from such disputes. The public's interest in the

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6/ UHF Comparability Task Force, Office of Plans and Policy, *Comparability for UHF Television: Final Report,* Federal Communications Commission, Sep. 1980 at 46. Relevant excerpts from the report have been attached to these comments as Exhibit A.

reception of over-the-air signals also plainly is not advanced by such litigation. The Commission can avoid these unnecessary disputes and harm to the television viewers by adopting specific standards as proposed by NASA in its petition for reconsideration of the *Reception Devices Order.*

For all these reasons, the Network Affiliated Stations Alliance urges the Commission to adopt a ruling in this proceeding in accordance with these comments.

Respectfully submitted,

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February 18, 1997

EXHIBIT A

EXCERPT FROM
COMPARABILITY FOR UHF TELEVISION: FINAL REPORT

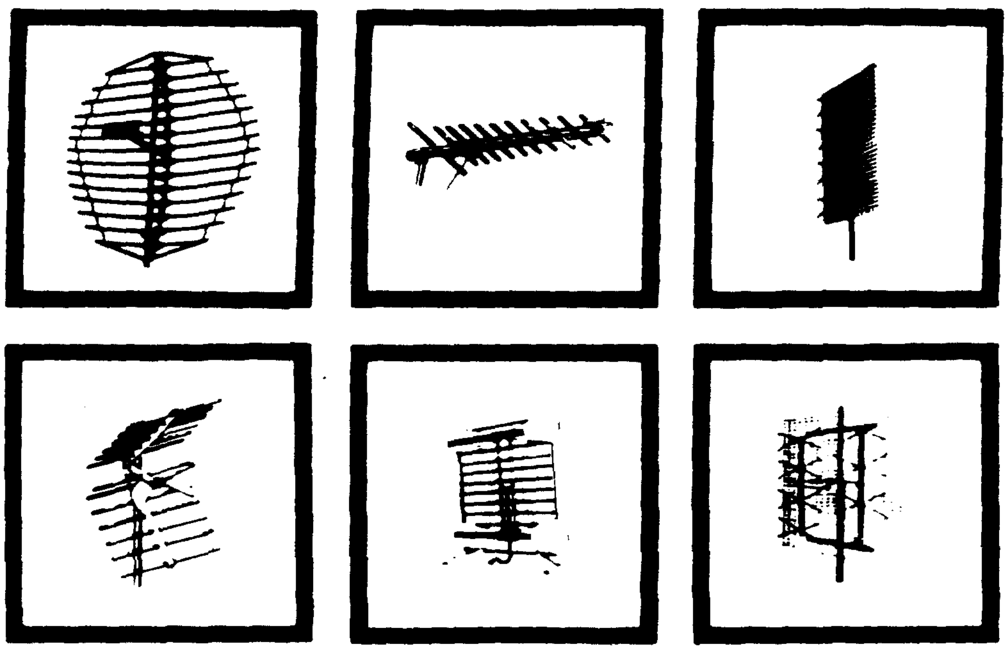
Released Sept. 18, 1980

Staff Report on:

File Copy

Comparability for UHF Television:

Final Report



UHF Comparability Task Force
Office of Plans and Policy
Federal Communications Commission
Washington, DC 20554

September 1980

CHAPTER 3

RECEIVING ANTENNA SYSTEM

The display of an image on the picture screen of a television receiver is the end result of the workings of all the parts in the broadcast television transmission/reception system: the transmission subsystem, the propagation medium, and the receiving subsystem.

The receiving subsystem can actually be further subdivided into two distinct parts: the receiver itself and the antenna system consisting of antenna, transmission line, and any associated components (for interfacing one device to another). The receiver will be discussed in a subsequent chapter of this report. This chapter will examine performance and cost tradeoffs between UHF and VHF receiving antenna systems. As with the propagation medium, laws of physics require different treatment between UHF and VHF channels in the performance of receiving antenna systems. By careful selection of antenna system parts, however, the handicap UHF signals face may be minimized at a reasonable cost.

Comparisons Between UHF and VHF Receiving Antenna Systems

In 1961 and 1962 the FCC funded an extensive engineering survey to determine the difference in UHF and VHF television reception in New York City (Deitz, 1962; Waldo, 1963). The NYC study appeared to indicate that, at least to distances up to 25 miles from a transmitting antenna, reception differences between low VHF (channels 2 - 6), high VHF (channels 7 - 13), and UHF, although real, were minimal. When looking at the results of the NYC study, one might conclude UHF television suffers very little from a signal strength "handicap" relative to VHF television.

Unfortunately, other data tell quite a different story. The Louis Harris and Associates survey conducted for the Task Force revealed that while nearly all the surveyed viewers predicted to receive at least one UHF and one VHF station received the VHF stations, only 73 percent received the UHF stations with <u>any</u> type of picture quality. What could account for this difference between UHF reception reflected in the two surveys?

One probable contributor to this discrepancy is the fact that the receiving installations in the NYC study were constructed by trained and experienced television technicians. The equipment was new and the antenna system was optimized for best reception. The viewers in the Harris survey had receiving installations that were installed by individuals with considerably less expertise than those technicians in the NYC study. In addition, the equipment used by Harris respondents (receiver, antenna, antenna lead-in line, etc.) was of all ages, and had been subjected to a wide range of weather conditions.

One area about which the UHF Comparability Task Force had considerable interest was in the relative performance of UHF and VHF receiving systems in the "real world." Information currently exists on the measured performance of antennas, transmission lines, and transmission line components, but the majority of this information was obtained through controlled laboratory measurements on the various parts of television receiving systems (FitzGerrell et al., 1979; Free & Smith, 1978; FitzGerrell, 1979). The Task Force's Preliminary Report estimated the relative performance of television receiving systems based on these controlled measurements (Gieseler et al., 1979). We remained uncertain, however, about the relationship between these estimates of performance and the performance actually being experienced by television viewers throughout the country. It seemed reasonable to assume that at least outdoor antenna systems might be subject to variations based on the age of the system, the amount of weathering it had experienced, and the degree of expertise that went into its installation. The Task Force decided investigation was needed to quantify the performance of actually installed receiving systems.

Investigation was approached on two fronts. Georgia Institute of Technology (GIT) was contracted to perform a follow-on study to the one they performed for the Public Broadcasting Service (PBS) in 1977 and 1978 (Free and Smith, 1978). GIT was specifically tasked to perform measurements on an additional set of antennas, at both UHF and VHF. Measurements were also performed on a variety of transmission lines, transmission line components, and television receiving preamplifiers (a preamplifier is an electronic device used in a receiving system to increase the power of the television signal fed to the receiver and improve the signal-to-noise ratio thereby reducing the amount of displayed snow). GIT was also asked to determine the effect that weathering, aging, and installation differences would exhibit on the performance of all these parts of the receiving system. The results of the GIT study will be examined later in this chapter.

The second approach the FCC used to quantify receiving antenna system performance was actually to measure a sample of viewer installed television receiving systems. The Institute for Telecommunication Sciences (ITS) was contracted to perform a measurement survey on a sample of 51 receiving installations in Illinois (Jennings and Juroshek, 1980). Constraints of time and money meant that the sample necessarily was small and that it could not be drawn in a way which insured it would be statistically random. As a consequence we must be cautious in drawing inferences from this sample because we cannot establish the statistical confidence that can be placed on such inferences. Nonetheless, we believe the results do provide useful information about the performance of receiving systems that viewers install. While the survey was not statistically valid, the results do provide a sense of the relative performance of receiving systems in the real world. Additionally, anecdotal information was obtained that confirmed laboratory measurements may tend to understate the relative disadvantage UHF receive systems suffer vis-a-vis VHF receive systems.

Generally, the effectiveness of an antenna is indexed against the effectiveness of some reference antenna. One of two reference antennas are routinely used. One is called an "isotropic" antenna. It does not physically exist, but is merely a theoretical representation of an antenna that receives signals from all directions equally well. The other commonly used reference antenna is called a "half wave dipole." This antenna may be thought of as the simplest antenna that can be constructed for use at a particular frequency. Many practical antennas are designed using a half wave dipole as a starting point. All the measurements reported in this chapter are referenced to a half wave dipole. When measuring antenna effectiveness referenced to one of these standards, the difference in signal levels at the output terminals of each antenna is determined (with both antennas positioned for maximum signal). The difference is then expressed as "gain", either positive or negative depending on the strength of the signal level from the test antenna relative to the reference antenna. The gain is routinely presented in terms of decibels, or dB, a common engineering shorthand for comparing signals or characterizing the way devices affect the level of signals.[1]

Table 3-1 summarizes laboratory measurements (from two previous ITS studies) and the measurements gathered in the Illinois field study. The summarized measurements are in the form of an overall receiving system effectiveness index referred to as "Television Receiving System Gain." This "gain" is a comparison between the signal level provided by the receiving antenna system to the receiver and the signal level that would be found at the output terminals of a half wave dipole.

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[1] To determine dB given a power ratio, simply take the common logarithm of the ratio and multiply this log by ten. Ratios greater than one will result in positive values of dB, and power ratios less than one will result in negative values of dB. For example, for a signal ratio of 10, the dB equivalent would be: $dB = 10 \log_{10} 10 = 10$. Similarly, the dB equivalent of a ratio of 100 equals 20 dB and the dB equivalent of a ratio of 0.1 equals -10 dB.

TABLE 3-1

Comparison of Estimated and Measured Television Receiving System Gains For Both UHF and VHF[1]

System Gain Based on Laboratory Measurements:

	Range	Average[2]
UHF:	-20.1 to 8.6 dB	-0.7 to 2.6 dB
VHF:	-18.3 to 9.6 dB	1.0 to 3.6 dB

System Gain Based on Field Measurements:

	Range	Average
UHF:	-39.3 to 15.2 dB	-5 to 0 dB
VHF:	-43.6 to 11.6 dB	0 to 5 dB

Notes:
1. Data from lecture by Jennings at ITS Symposium, October, 1979, based on FitzGerrell et al. (1979) and Jennings (1980).
2. The range of averages represents the average gain for a variety of different system configurations. The low end of this range is the average gain for the worst systems; the high end of this range is the average gain for the best systems.

The very wide range of measured system performance for the actual receiving installations, shown in Table 3-1, is striking when compared to the estimated system gain ranges. The higher gain figures in the measured system ranges are due to systems using very sophisticated receiving antennas--antennas that were not included in the estimated system gain figures. But why do the measured system ranges for UHF and VHF show low ends that are approximately 20 dB less than the estimated system gains? The additional signal loss occurs as a result of some combination of the following three areas:

- installation of the antenna system. This includes probing of the general area the antenna is to be installed to locate the spot where signal strength is greatest. If the antenna is not oriented for maximum signal strength system gain will decrease. In addition, the physical placement and connections between antenna, transmission line, components, and receiver, if not done properly, can increase signal loss;

- weathering of the antenna system. The effect of moisture on the elements of the system can cause oxidation of exposed metal parts, including transmission line, which can increase signal loss. Just the presence of moisture on the line can also increase the loss of signal in some types of transmission lines;

- aging of the antenna system. After exposure to seasonal weather extremes, system elements may become brittle and dirty and may result in increased signal loss;

- errors inherent in the methodology of the experiment. Specifically, measured television field strength was assumed to be the same at the home receiving antenna as it was in the street where the measurements were made.

Therefore, the overall antenna system performance depends not only on the measured gain or loss of each system element, but also on how this measured value will vary as a result of installation practices, weathering and aging. Some types of antenna system elements exhibit much less variation in performance than others. Unfortunately, the consumer may not have a guide to the receiving system elements other than price, and it is clear that UHF antennas with the highest gains do not have the highest price tags. Even the measured gains and losses of the various parts of a receiving antenna system may not be readily available for all types and models of components, let alone the variation these gains and losses may undergo in actual installations.

This chapter will examine the cost and performance of the parts of the antenna system, and how the necessary information for informed purchasing can be conveyed to the consumer in a manner that makes comparisons possible. In addition, improved UHF reception through the use of preamplifiers will be discussed.

Antennas

The receiving antenna is the first element in the receiving system that differentiates treatment between UHF and VHF television signals. Because it is positioned at the very beginning of the system, the system performance may be only as good as the antenna.

An antenna's performance is directly related to its size. The size of an antenna, however, must be such that the radio waves it is trying to intercept "fit" the antenna. Since radio signals have a physical length, the "wavelength," the physical dimensions of an antenna designed to intercept a particular frequency radio signal must be related to the signal's wavelength for optimal performances.[2] This means the size and shape of an antenna are determined in part by the frequencies, or channels, the antenna is designed to receive.

Since the wavelength of a radio signal is inversely related to its frequency (and television channel numbers increase with frequency), and receiving antenna gain is referenced to a standard antenna one half wavelength long, UHF and VHF antennas that have the same measured gain, will have different physical dimensions. The VHF antenna will be physically larger. Because it is physically larger, the VHF antenna will more efficiently intercept radio signals than the UHF antenna--even though measured gains of the antennas are equal. This difference in efficiency between antennas of different frequencies is known as the "dipole factor."[3]

The FCC has recognized the difference in receiving antenna effectiveness due to the dipole factor, and currently allows UHF broadcasters to operate at

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[2] Radio signals travel through space at the speed of light, $c = 3 \times 10^8$ meters/second. Since a signal's frequency is a measure of how quickly it is changing amplitude in cycles per second (called Hertz or Hz), a measure of the distance a radio signal travels between equal amplitudes of the signal can be calculated by dividing the speed the signal is traveling (c) by its rate of change, frequency (f). This value c/f is called the wavelength of the signal and is symbolized by the Greek letter lambda (λ). In order for a signal to just fit a receiving antenna, the antenna must present to the signal dimensions that are electrically near a multiple of a half wavelength.

[3] If channel 2 (VHF) and channel 14 (UHF) dipoles are intercepting radio frequency energy of equal strength at their respective frequencies, the output signal voltage will be 18.8 dB greater for the channel 2 antenna. For a detailed treatment of the "dipole factor," see Rubin (1974).

much higher powers than VHF broadcasters.[4] Does this increase in the allowable amount of broadcast power compensate for poorer UHF antenna performance? The answer to that question is no, for four reasons. First, as a later chapter in this report details, the cost of running the maximum allowable power may be prohibitive for the UHF broadcaster. Secondly, besides the system inefficiency due to the dipole factor, all the other elements of the receiving system discriminate against UHF signals, too. Thirdly, while the size required for very high gain antennas is small for UHF relative to VHF, measured performance of a wide variety of UHF and VHF antennas indicates that UHF antennas are not likely (on the average) to have significantly higher gain than VHF antennas (i.e., do not overcome the dipole factor). Finally, the Harris survey showed that viewers are less likely to use an outdoor UHF antenna than an outdoor VHF antenna (Harris, 1980). The difference in the television signal strength provided by an indoor antenna system versus an outdoor antenna system is very large for both VHF and UHF signals. The NYC study estimated the difference to be between 12 dB (channel 2 measured inside a wooden structure) and 28 dB (channel 31 measured inside a reinforced concrete structure). The ITS/Chicago data analysis indicated a difference in signal strength of as much as 30 dB between indoor and outdoor systems.

In the Task Force's Preliminary Report, published in September 1979, antenna gain averages and ranges were presented. It was found that many

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[4] FCC Rules limit broadcasters on both power and antenna height. For most parts of the country, television broadcasters are limited to a maximum antenna height of 2000 feet (1000 feet for VHF stations in the northeastern portion of the country). Low band VHF stations, channels 2 through 6, are limited to a maximum effective radiated power (ERP) of 100,000 watts (100 kilowatts, kW); high band VHF stations, channels 7 through 13, are limited to a maximum ERP of 316 kW: and, UHF stations are limited to a maximum ERP of 5000 kilowatts (5 Megawatts, MW).

TABLE 3-2

Comparison of Measured VHF and UHF Antenna Gains

(Referenced to a Half Wave Dipole)

Antenna Type	Range	Most Likely[5]	Low VHF Average	High VHF Average	UHF Average
Outdoor					
UHF Only[1]	0.5 to 16.0	5.3 to 12.2	- -	- -	8.75
V/U Combo UHF[1]	-5.5 to 15.5	3.15 to 11.3	- -	- -	7.21
V/U Combo VHF[1]	1.2 to 10.6	1.7 to 8.6	3.80	7.03	- -
VHF Only[2]	1.2 to 10.4	- -	4.4	8.3	- -
Indoor					
UHF[3]	-18.5 to 8.5	-7.3 to 3.1	- -	- -	-2.1
VHF[4]	-2.3 to -6.0	- -	-3.6	-3.5	- -

NOTES:

1. Data compiled from GIT measurements (Free & Smith, 1978; Free et al., 1980).
2. Data measured and originally reported in National Bureau of Standards (NBS) Report 6099, by A. C. Wilson. Data in this table from FitzGerrell et al., 1979. Individual antenna measurements unavailable to compute "Most Likely."
3. Data compiled from GIT measurements (Free & Smith, 1978; Free et al., 1980) and ITS (FitzGerrell, 1979).
4. Data from ITS (FitzGerrell, 1979) includes only a sample of two antennas. Therefore, no computation of "Most Likely" was performed.
5. Range of values in this column computed by adding and subtracting the sample standard deviation, s, to the arithmetic mean of the gains.

$$s = \sqrt{\frac{n\,\Sigma x^2 - (\Sigma x)^2}{n(n-1)}}$$

where n = number of gain measurements
x = each individual gain value

6. Data presented for UHF channels includes measurements on frequencies between channels 14 and 64 inclusive.

antenna types exhibited average UHF gains less than the average high band VHF antenna gain.[5]

Table 3-2 summarizes the expected antenna gains of different types of antennas (Free and Smith, 1978; FitzGerrell et al., 1979; FitzGerrell, 1979). The average gain values seem to bear out the conclusions reached in the Preliminary Report: UHF-only antenna gain (as compared with combination UHF/VHF antennas) is less than 0.5 dB greater than the VHF-only antenna gain in the high VHF band, while the average UHF gain on a combination antenna is nearly equal to the average high band VHF gain on a combination antenna. In all cases the low band VHF gain is a few dB less than the high band VHF gain. The indoor antennas all appear to have relatively poor average performance, with the UHF indoor antenna gain average being slightly greater than either the high band or low band VHF indoor antenna gain. But the range over which the UHF indoor antenna gain varied indicates that one might have a better chance of having an indoor UHF antenna with poorer performance on a particular channel than a VHF indoor antenna on a particular channel.[6]

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[5] Most VHF antennas are designed to cover both low band VHF (channels 2 through 6) and high band VHF (channels 7 through 13).

[6] It is important to remember when evaluating this data, and all the average gain data presented in this chapter, the average gain does not necessarily indicate one antenna may outperform another at a particular channel. While antennas with consistently high gains across the UHF television band will have high average gains, an antenna with a lower average gain figure might exhibit higher gain on the particular channel a viewer wishes to receive than the higher average gain antenna model. Additionally, antennas are also specified in terms of beamwidth, which is an index of the criticality of pointing the antenna at the transmitter to obtain the strongest signal. Beamwidth is not addressed at all in this chapter, because in most outdoor installations, we do not believe it is a critical factor. For indoor antenna systems, however, beamwidth may be a more critical performance parameter. This is particularly true for receiving systems that are in a high signal strength area, but whose reception is plagued with multiple images (ghosts). See footnote 10.

Table 3-2 also indicates that performance from a UHF only antenna may be somewhat better than that obtainable from a combination antenna. In an effort to examine this area more closely, and, simultaneously, to examine the cost tradeoffs involved in the purchase of separate UHF and VHF antennas versus combination antennas, the GIT/ITS data was broken down into various generic antenna types for UHF.

Table 3-3 presents some expected gain data for a variety of antenna types--both UHF-only antennas and the UHF section of UHF/VHF combination antennas. (According to the Harris data, most UHF outdoor antenna installations utilize combination UHF/VHF antennas.)

While Table 3-3 suggests this difference between combination and separate antennas is worth very little in terms of received (1 to 2 dB) picture quality, "real world" evidence suggests the difference between these types of antennas may be very large. The ITS/Chicago data showed a 12 dB UHF system gain difference between systems using UHF-only antennas and systems using combination UHF/VHF antennas. This 12 dB difference can change perceived picture quality two TASO Grades (from "marginal" to "fine" for instance). We tend to believe the ITS data is closer to the real world performance of combination antennas than are the laboratory measurement data because of the results of the Harris survey where such a large percentage of viewers, including those using outdoor combination antennas, did not receive the number of UHF stations that computer estimations predicted.

Of course, in most television markets, viewers want both UHF and VHF programming, so when purchasing an antenna they may buy a single combination antenna for convenience, rather than having to install two separate antennas. But, clearly, a separate UHF-only antenna would provide superior performance. It seems, therefore, it would make good sense to buy separate

UHF and VHF antennas. What are the differences in costs between a separate antenna system and a combination antenna system? Areas where cost differences might occur can be identified:

- cost of buying a combination antenna versus buying separate antennas;
- cost of two (versus one) lead-ins or the cost of components necessary to utilize a single lead-in from two antennas (a combiner);[7]
- costs of installing two antennas versus installing one antenna.

Installation cost for the two antenna systems might be slightly higher than the one antenna system, but the actual cost of one antenna versus two antennas should be roughly equivalent.[8] The only real cost difference between the two systems is likely to be as a result of lead-in cost differences. Even in this area, however, the relative difference in cost should not exceed 10%

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[7] Salvati (1979) described several combination balun/combines (for combining two 300 ohm antennas into one coax cable) and balun/splitters (for splitting the single coax lead into a VHF and a UHF 300 ohm outputs to the receiver). Salveti measured insertion loss in these devices of between 0.8 and 1.2 dB at 550 MHz (approximately channel 27).

[8] In order to compare the cost of a combination antenna with the cost of two separate antennas, average cost information is needed for all these antennas. We did not obtain any price performance information on VHF-only antennas. We speculate, however, that the average price of a VHF-only antenna would be reflected by the average price of a Radio Shack (Tandy) VHF-only antenna--about $31.00 (1980 Radio Shack Catalog).

Using this estimate of average VHF-only antenna price ($31.00), the cost of two antennas would be roughly equivalent to the cost of one antenna. The antenna with the highest measured gain, the eight-bay bowtie, would add $32.00 to the average VHF-only antenna cost, making the cost of these two antennas together $63.00 compared to the $61.00 for the VHF/UHF combination antenna with yagi/corner reflector UHF portion. Similarly, the cost of the four-bay bowtie--$10.00--would make the cost of two antennas $41.00, which is slightly more than the average cost of the log periodic type combination antenna, $36.00. In both these instances, the measured gain of the separate UHF antenna is much greater than the measured gain of the UHF portion of the combination antenna.

TABLE 3-3

Measured Gain, Cost Summary for UHF Outdoor Antennas

(Gain Referenced to a Half Wave Dipole)

Antenna Type	Range	Most Likely	Average	Average Cost[5]	Number of Antennas
UHF Only					
8 Bay Bowtie with screen	9.5 to 15.0	-	13.4	32.00	1
5' Parabolic	-2.3 to 7.9	-	4.1	61.00	2
Log Periodic	2.4 to 14.0	4.8 to 10.4	7.6	20.00	2
Single Bowtie with corner reflector	0.5 to 12.0	5.2 to 10.5	7.8	9.00	2
4 Bay Bowtie with screen	5.5 to 16.0	7.3 to 14.1	10.7	10.00	3
Yagi with corn. refl.	3.8 to 14.0	5.3 to 11.8	8.6	18.00	5
VHF/UHF Combination					
Log Periodic	-.5 to 11.5	1.9 to 7.4	4.7	36.00	3
Yagi with corn. refl.	-5.5 to 15.0	3.3 to 12.2	7.8	61.00	6

NOTES:

1. Data compiled from GIT (Free & Smith, 1978; Free *et al.*, 1980).
2. "Most Likely" is computed from sum and difference of arithmetic mean and sample standard deviation. Those antennas that do not have an entry in this column had an insufficient number of measurements to make these values meaningful.
3. All gain values in dB.
4. Data presented includes measurements on frequencies between channels 14 and 64 inclusive.
5. Cost from Free *et al.*, (1980).

of the total cost of the system (less installation). This percentage assumes the cost of lead-in is $5.00, and the cost of a UHF/VHF combination antenna system, including lead-in but less installation, is $50.00. The cost of a combiner and band-separator, both of which are necessary to use a single lead-in with two antennas, would be roughly $5.00, also.

The advantages of the two antenna system are numerous. Besides the performance difference already mentioned, the UHF antenna may be "aimed" at the desired television transmitters independently of the VHF antenna. This is obviously an advantage in areas that have transmitters located at widely differing geographic locations (which is much more likely in small markets). It also is advantageous where transmitters are co-located, but aiming is different on UHF and VHF because the antenna's maximum gain may not be on the same axis for both the sections of a combination antenna. Also, a receiving antenna site may be shadowed from the direct path of the television signal from the transmitting antenna, and some slight rotation of the receiving antenna may result in a stronger, reflected signal. This type of propagation would not be expected to occur to the same degree for both VHF and UHF signals. A mechanical rotor could also be used to alleviate these problems, but at a much higher cost.

Indoor antennas

Many viewers find themselves in a situation where they cannot or do not wish to erect an outdoor antenna system, and must make do with indoor antennas. Indoor antenna systems suffer from three main disadvantages when compared to outdoor antenna systems. First, the direct signal is often reflected many times within the room and the receiving antenna is intercepting more than one television signal from the desired station. This can result in severe distortion of the displayed television image, usually manifested as multiple images, or "ghosts." The second disadvantage, as Table 3-1 indicated, was the great difference in expected gain between indoor antennas and outdoor antennas. Third, because indoor antenna systems are likely to be at a lower height than outdoor systems, and the television signal must penetrate the exterior of the building to reach the receiving antenna, the amount of signal power that is available for interception by the receiving antenna tends to be reduced.[9] These three items combined can result in a snowy and distorted picture on the television receiver. Harris confirmed that viewers with indoor antenna systems are much more likely to experience a variety of types of picture degradation than viewers with an outdoor antenna systems.

Despite all these problems facing an indoor antenna installation, a viewer can in some instances obtain an acceptable picture. In order to do so, the viewer must accurately identify the reasons his picture is unacceptable, and then purchase the appropriate components to improve it. If the reception

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[9] Several papers have attempted to quantify the difference in signal power between indoor and outdoor antenna systems caused by differences in antenna height and the attenuation of the radio energy by the material used to construct the building (building attenuation). An FCC report published in 1963 revealed differences in measured signal strength between rooftop and indoors varied between 12 dB and 28 dB depending on the channel (frequency) measured and the building material (Waldo, 1963). Other reports indicate losses of approximately 12 dB for UHF channels (FitzGerrell, 1979). This chapter will use for an "indoor handicap" a value of 13.0 dB for VHF channels and 11.8 dB for UHF channels per FitzGerrell. This indoor handicap does not take into account a slight net gain in indoor system performance due to less transmission line attenuation. This is a different value than is used to derive an "indoor antenna contour" (see Appendix B), principally since the indoor contour assumes dense urban structures that tend to have greater attenuation than suburban residential buildings.

problem is antenna adjustment to minimize ghosting (multiple images), then the purchase of a more directional antenna may be the answer.[10] If the major problem with a particular viewer's television reception is a snowy picture, then the purchase of an antenna with a higher gain will help reduce the snow in the picture. Table 3-4 examines the average gains of a number of the more popular indoor antenna designs. Note that the antenna with the highest average gain is not the most expensive. (In fact, the "top of the line" model with the highest price tag had the worst gain.) The difference in gain between the traditional loop or bowtie antennas that come with many television receivers and the double bowtie with screen antenna is nearly enough to improve picture quality by one grade at a cost of less than ten dollars. By using a double bowtie antenna and "probing" to determine the location in the room where signal strength is greatest, reception may prove satisfactory.

If a double bowtie antenna does not make reception satisfactory, and an outdoor antenna system is out of the the question, another method for decreasing the amount of snow in a television picture fed with an indoor antenna system, is through the addition of a receiving preamplifier.[11] In another Task Force report, the use of preamplifiers to reduce the amount of

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[10] While antennas for most radio services are specified by the forward gain, which implies directionality, TV receiving antennas specifications may be more meaningful if they include both forward gain and directionality: beamwidth--the angle encompassing the -3dB points, relative to maximum gain; front to back ratio--the difference in dB between the maximum gain off the front of the antenna and the antenna's response off the back of the antenna; and, front to side ratio--similar to the front to back ratio except comparing antenna response off the front and off the side.

[11] A radio frequency preamplifier is a device that can be used in a receiving antenna system to provide gain so that a signal may be further processed without appreciable degradation in signal to noise ratio (IEEE, 1977).